IFA Indonesia Seminar on
Sustainable Fertilizer Management

K and Mg dynamics in oil palm nutrition

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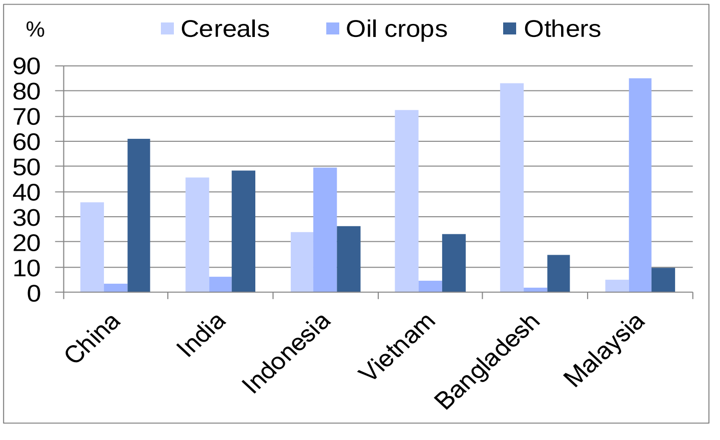
E-SEA: Potash use by crop type in % of total



Source: Heffer, 2009

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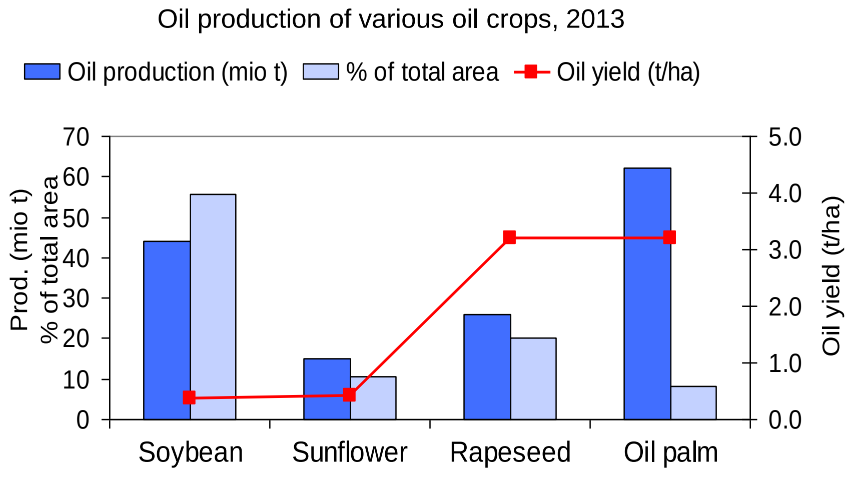
Oil palm highest oil production per unit area



Source: based on Oil world, 2013

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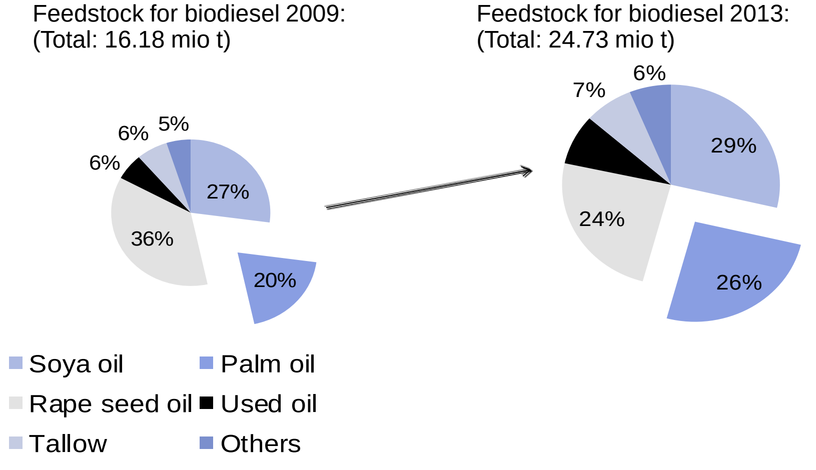
Growing use of palm oil as feedstock for biodiesel



Source: Oil World, 2013

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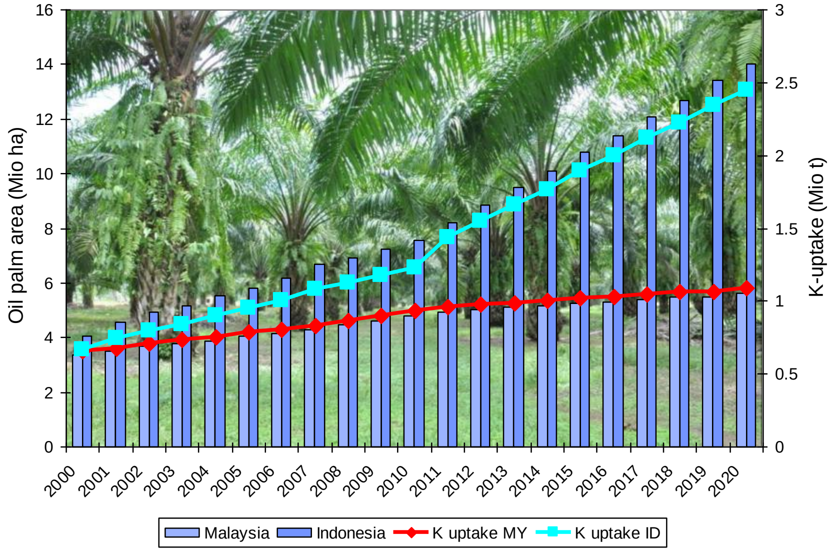
Oil palm expansion, a driving force for K use



Source: USDA, 2010, MPOB, 2010, IPNI

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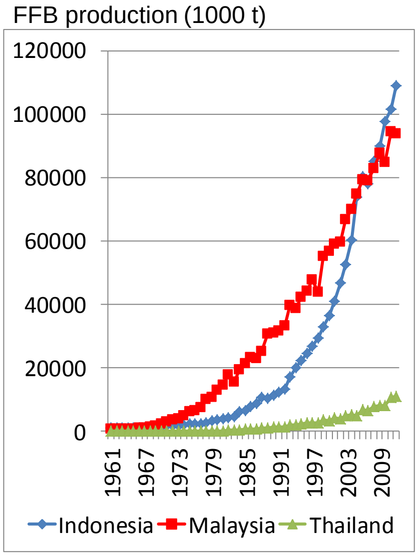
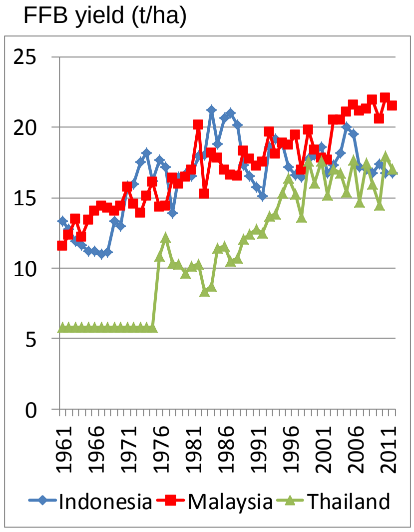
FFB production and yield in SE-Asian countries





Current FFB yield in Indonesia only 17 t/ha!

Source: FAO, 2014

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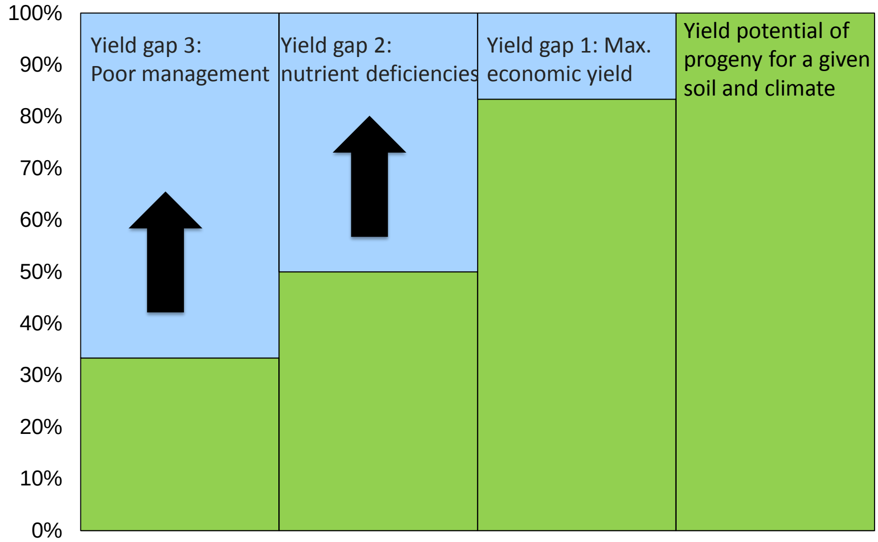
Yield Gaps . . .



Source: Oberthuer and Donough, 2012

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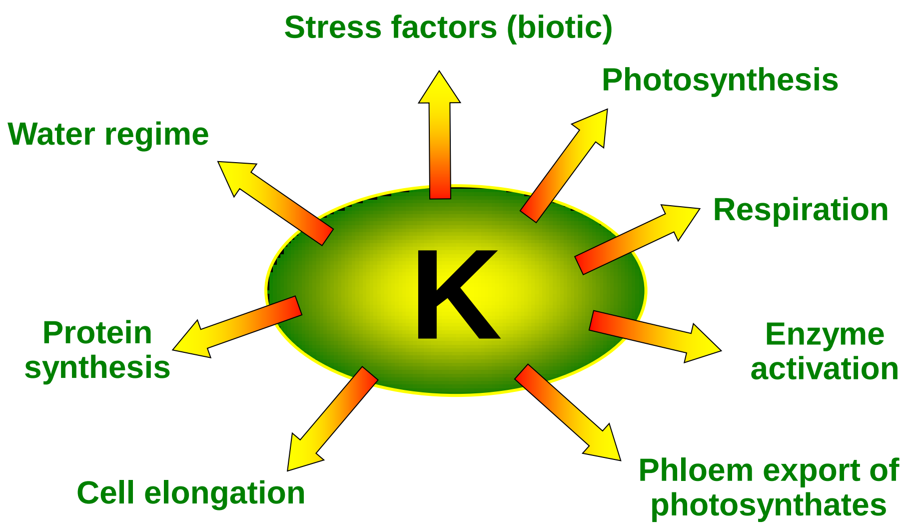
Role of K in crop production and plant metabolism



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Role of Potassium (K) in oil palm

- potassium plays an important role in the conversation of light in biochemical energy during photosynthesis
- *potassium is the quantitatively most important cation*
- potassium speeds up the flow of assimilates and promotes the storage of assimilates
- potassium is required by more than 100 enzymes
- potassium improves the water utilisation of crops
- potassium is the most important inorganic osmoticum and increases the drought tolerance of crops

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Symptoms of K deficiency related to its function

Lack of K induces sudden cell damage of isolated leaf regions → 'orange spotting'

Confluent orange spotting

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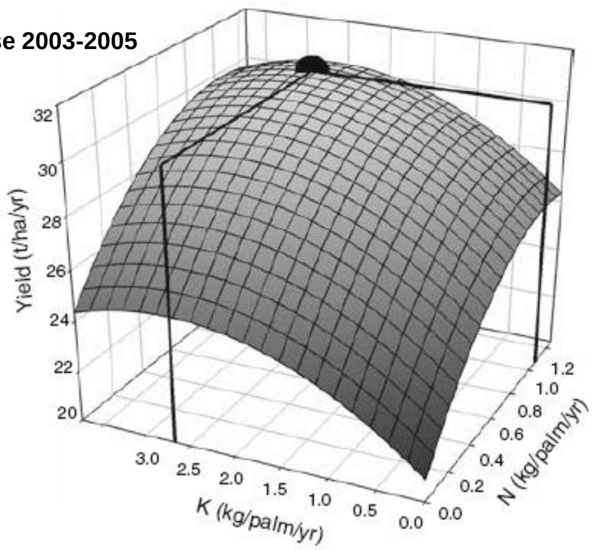
N x K interaction: Yield contour plot

Average yield response 2003-2005



Source: Webb, 2009

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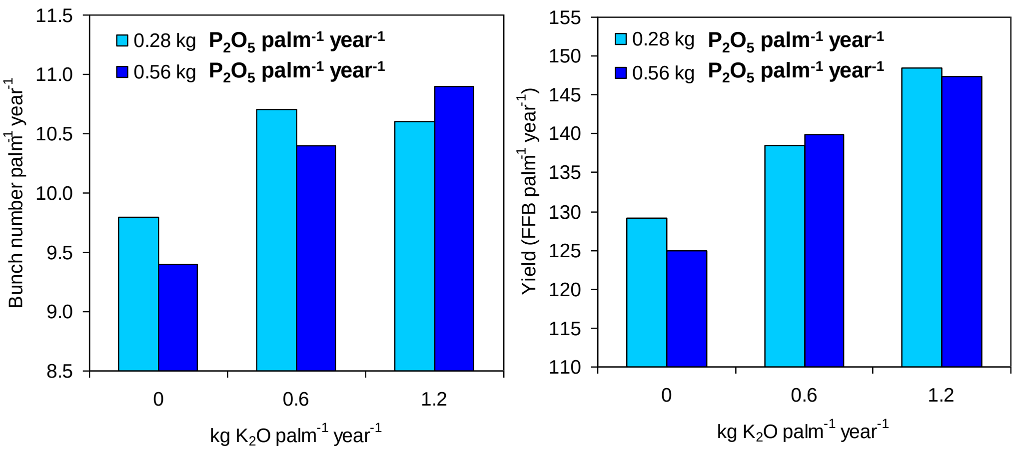
Yield of oil palm as affected by K and P supply



Potassium promotes bunch development and bunch yield!

Source: Kusnu et al. (1996)

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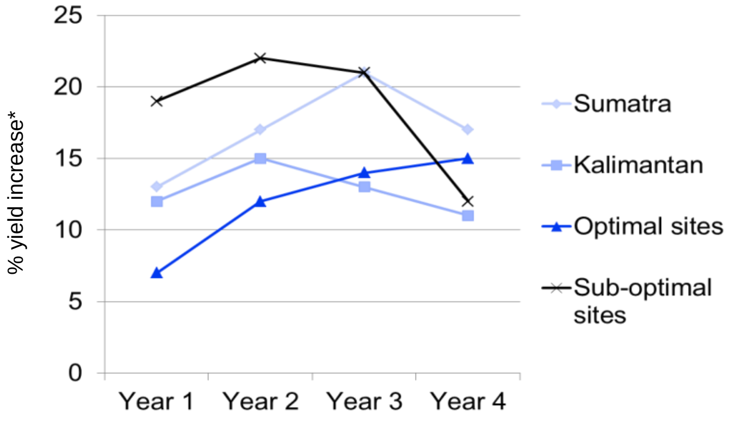
Oil palm: Best management for larger yields



*Fresh fruit bunch yield increase in Best management plots over reference plots

Source: Oberthuer et al. 2013

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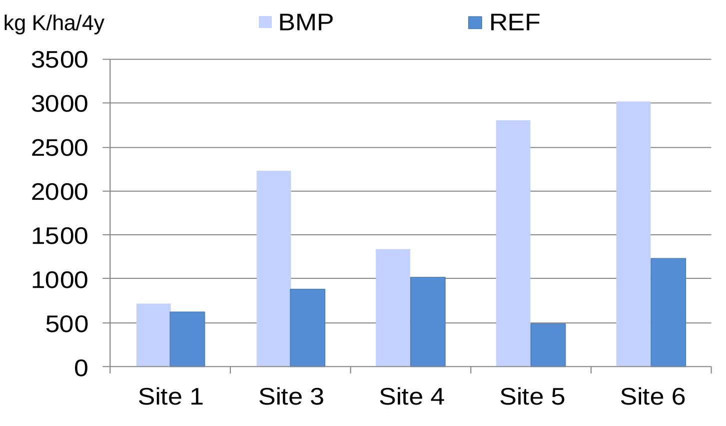
Oil palm: BMP increases K application



*Total K application (organic plus inorganic) in BMP plots compared to REF plots over a period of 4 years

Source: Oberthuer et al. 2013

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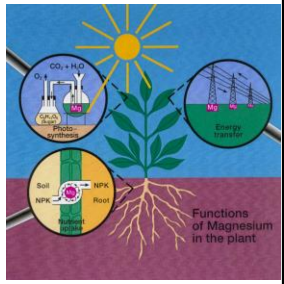
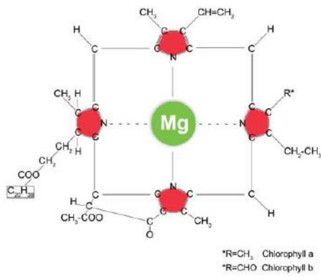
The roles of Mg in plant growth and metabolism

- **Protein synthesis**
- **Translocation of assimilates from leaves to fruits, buds, & roots (→ nutrient uptake!)**
- **Photosynthesis**
  - **Central atom of chlorophyll**
  - **Chloroplast function and activation of CO_2-Fixation (*counter ion*, pH changes)**
- **Activation of numerous enzymes**





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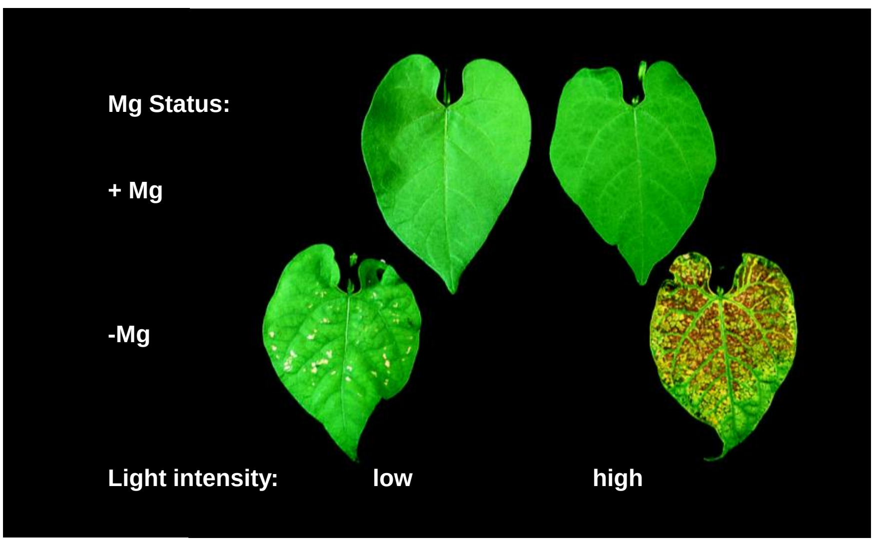
No expression of Mg deficiency symptoms under Conditions of low light intensity!



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Symptoms of nutrient deficiencies are related to their function:

Magnesium is required for chloroplast function and activation of photosynthesis (CO_2-Fixation)

→ lack of Mg induces oxidative stress, because light energy cannot be used to produce assimilates (sugar)

→ Mg-deficient leaves are more sensitive to sunlight!

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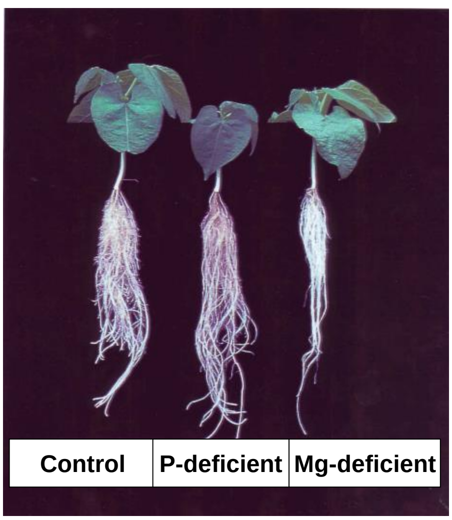
Function of Mg in plants: No other nutrient is so critical for assimilate translocation to roots and fruits!



A P-deficient plant translocates more assimilates to the root, enhancing root growth.

A Mg-deficient plant responses the opposite way and root growth is severely inhibited.
This has major consequences for nutrient uptake!

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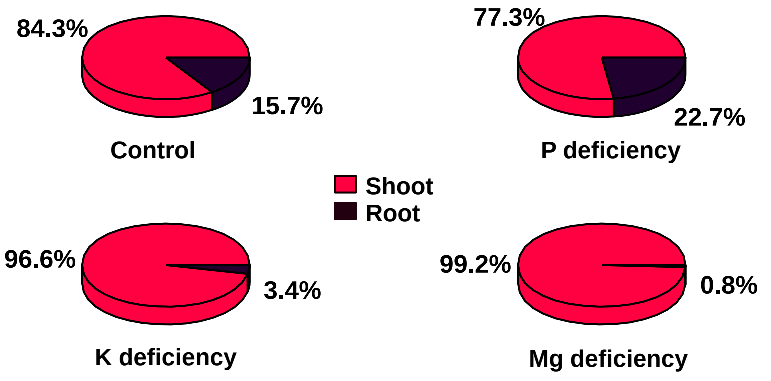
Function of Mg in plants: No other nutrient is so critical for assimilate translocation to roots and fruits!



Relative distribution of carbohydrates between shoot and roots of 12-days-old bean plants grown in nutrient solution with deficient supply of P, K and Mg

Source: Cakmak et al., 1994

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The effect of Mg on FFB and oil yield

Treatment	Year 5 (t ha^{-1})	Years 1-5 combined (t ha^{-1})	Oil to bunch ratio
N+P+K	4.35 b	6.00	27.90
N+P+K+1.5 Mg	5.92 a	6.54	28.49
N+P+K+3.0 Mg			29.27

- Magnesium (Kieserite) significantly increased FFB yield, oil content (O/B) and oil yield
- An extra 0.57 t ha^{-1} year^{-1} oil was obtained by application of 1.5 kg Mg palm^{-1} year^{-1} as ESTA Kieserite

Source: Dolmat, MPOB, 2005

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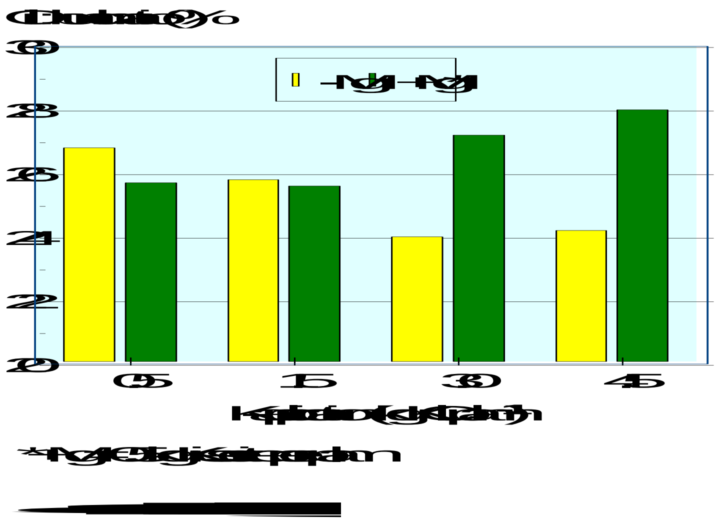
The interaction of K and Mg on oil : bunch ratios of oil palms



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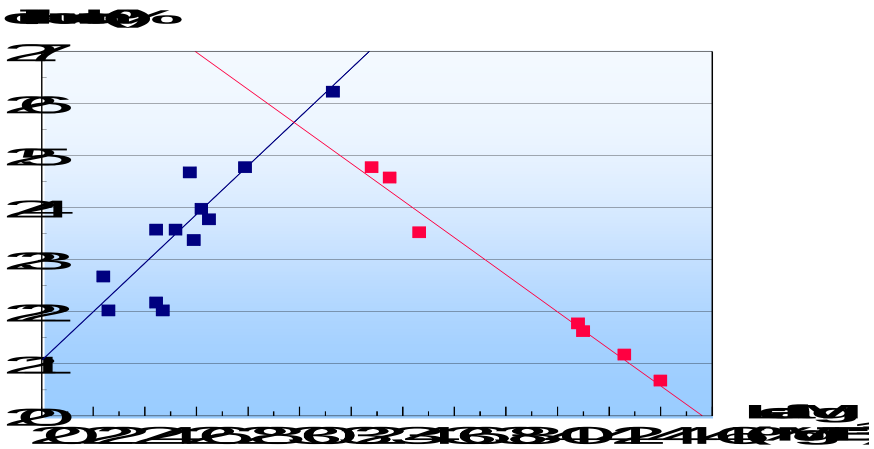
The relation between leaf Mg contents and oil : bunch ratios



Source: Based on Foster, 2003

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The 4 R's principle (IPNI):

Right type - Magnesium fertilizers

Magnesium sulphate (ESTA Kieserit, $MgSO_4 \bullet H_2O$):

- does not affect soil pH
- fully water soluble, plant available
- availability not affected by soil pH
- also provides sulphur (S)

Dolomite ($CaCO_3 \bullet MgCO_3$; dolomitic limestone, GML) Magnesit ($MgCO_3$) and calcined magnesit (MgO):

- increases soil pH when used in large amounts (→ liming material!)
- not water soluble, not immediately available
- Mg availability dependent on soil pH
- Ca content may interfere with K or Mg absorption (Dolomite)

→ **The choice of Mg fertilizer needs careful attention**

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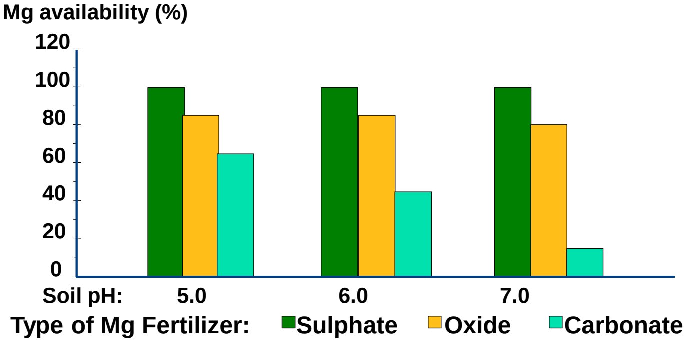
Comparative efficiency as affected by soil pH

Relation between soil pH and availability of Mg from different sources



Kieserit-allg

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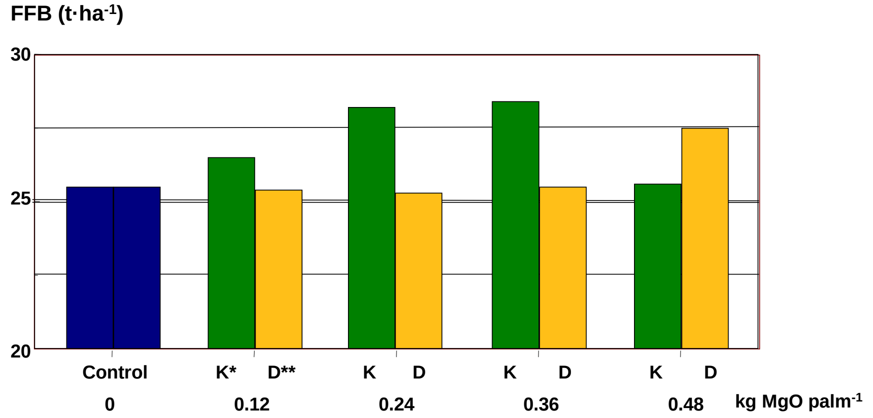
Mean FFB yields on a Rengam series soil as affected by kieserite and dolomite application

[redacted]



* K = Kieserite

**D = Dolomite

Source: Mohd Hussin et al. (1998) Kemajuan Penyelidikan Bil. 31: 29-34

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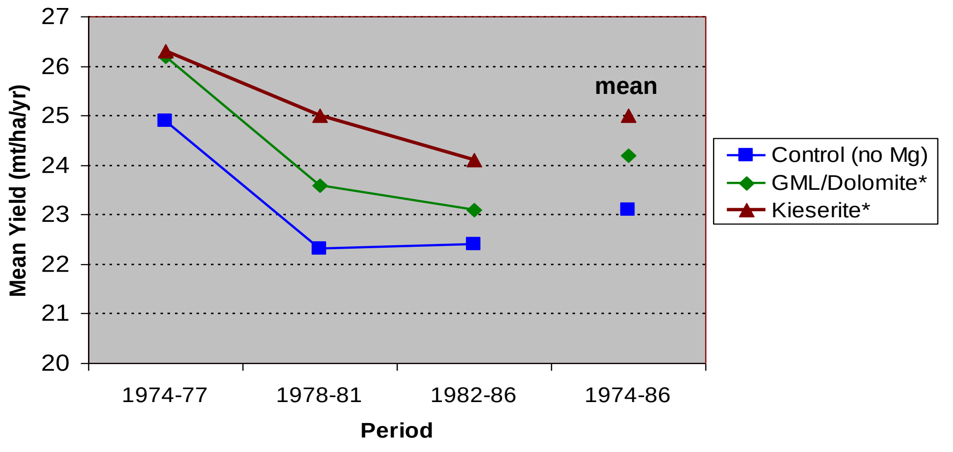
Effect of Mg Fertilization on Oil Palm Yield on Sedu series



* Equivalent to 0.80 kg MgO /palm/yr

Source: Gurmit Singh, 1990

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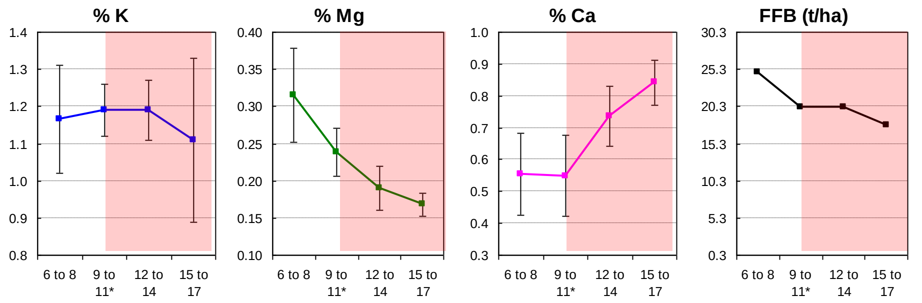
Impact of replacing Kieserite by Dolomite on K, Mg and Ca Contents of Frond #17, and Yield over 6 years



*** Start of GML/Dolomite use after 11th year using Kieserite**

Strong antagonistic effect of calcium on potassium and magnesium → yield depression!
→ Avoid high Ca sources (dolomite, rock phosphate)

Source: Ng, Thong, Ooi & Leng, 1995

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Nutrient interactions (synergisms and antagonisms)

- **Nutrient interactions**
  - **Antagonisms (uptake of two nutrient shows negative interference)**
    - **Indirect (soil nutrient dynamics): One nutrient reduces availability of another one (Ca precipitates phosphate in soil)**
    - **Plants have limited capacity for uptake of anions and cations: Excessive supply of one nutrient impairs uptake of those of the same charge (→ uptake competition):**
      - **Ca × Mg competition and Ca-induced Mg deficiency**
      - **Ca × K competition and Ca-induced K deficiency**
      - **K × Mg interaction and K-induced Mg deficiency**

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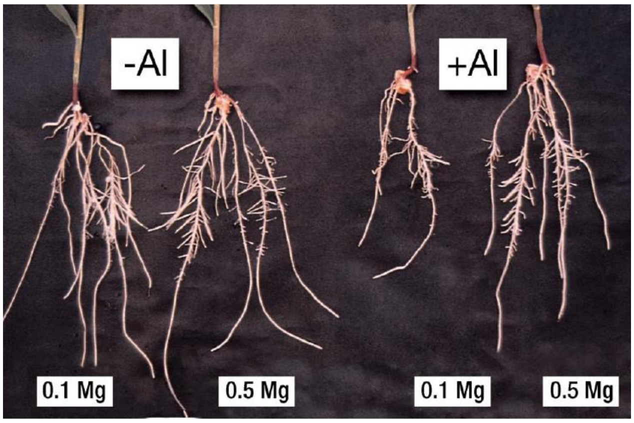
Agronomic features of ESTA Kieserite: Mg overcomes Al-induced root growth inhibition



Magnesium alleviates aluminium toxicity and hence ensures a high nutrient efficiency of crops grown under acid soil conditions !!!

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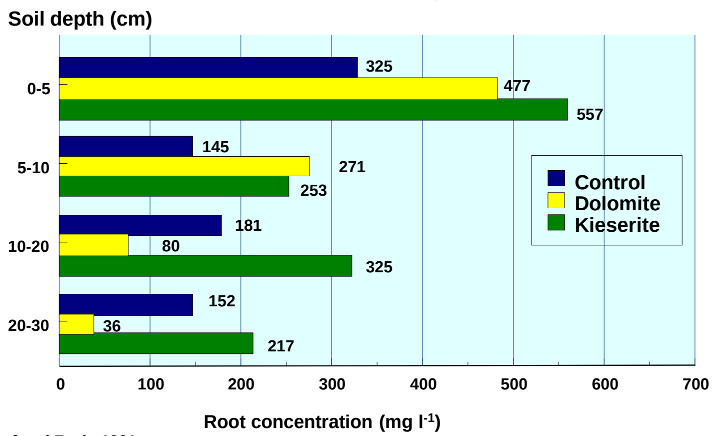
Effect of Mg-sources on root growth at low soil pH

Distribution of feeder roots (< 2 mm) of Norway spruce on an acid forest soil (pH 3.7) as affected by the Mg nutrition



Source: Schaaf and Zech, 1991

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Summary

- **Oil palm has the greatest potential in producing vegetable oil**
- **It is and will remain the driving force for K consumption in Indonesia**
- **Both expansion in suitable areas and intensification of existing areas will lead to a higher input of this nutrient**
- **For optimal exploitation of the yield promoting effect of K, its application has to be well balanced with other cations, i.e., magnesium**
- **Balanced application and matching availabilities is essential to realize maximum economic yields, especially on the widespread acidic conditions, where inhibited root growth is limiting the water and nutrient uptake of the crops.**

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Mg and K dynamics in oil Palm